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Effects of maxillomandibular advancement on systemic blood pressure in patients with obstructive sleep apnoea

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Abstract

Obstructive sleep apnoea (OSA) is associated with resistant hypertension. We investigated to what extent maxillomandibular advancement affected a patient's blood pressure postoperatively. We retrospectively analysed consecutive patients who had Bimaxillary advancement for OSA at our hospital following referral from the local sleep clinic. We collected relevant data on clinical characteristics and explored the changes in systolic and diastolic blood pressures, as well as mean arterial pressure (MAP) preoperatively, with those taken 6 months following surgery. We identified 51 patients with a mean (SD) age of 44 (8) years and a mean (SD) body mass index of 29 (3.4). Preoperative and postoperative data on blood pressure were available for analysis in 45. The mean (SD) systolic blood pressure was significantly reduced in our sample following surgery (from 131(12.6) to 127 (12.5) mmHg, $p < 0.001$). The mean (SD) reduction in postoperative MAP values in the overall group, approached statistical significance (recorded MAP 96.6(10) to 93.1(8) mmHg, $p = 0.06$). In a subgroup of 10 patients who had established hypertension the reduction in values postoperatively (mean reduction: systolic blood pressure 6 mmHg, diastolic blood pressure 10 mmHg, mean arterial pressure 9 mmHg) was greater than that observed in the overall group. Our results have shown an improvement in systemic blood pressure after maxillomandibular advancement for OSA, particularly in those with established hypertension. The data suggest that in addition to being a highly effective treatment for OSA, this surgery may more effectively lower systemic blood pressure than other treatment modalities.

Keywords: Maxillomandibular advancement surgery; Orthognathic surgery; Systemic blood pressure; Modification; Obstructive sleep apnoea; Hypertension

Introduction

Obstructive sleep apnoea (OSA) is characterised by the periodic narrowing of the upper airway with associated cessation (apnoea) and reduction (hypopnoea) of airflow during sleep. It is a common condition worldwide and is well known to cause hypertension, stroke, sudden cardiac death, and other metabolic disorders.[1–3]

Hypertension is recognised as an important risk factor for cardiovascular disease and is amenable to treatment. OSA, which adversely affects blood pressure, is one of the most common risk factors for resistant hypertension.[4] Patients with 'resistant' hypertension require multiple anti-hypertensive agents to achieve adequate blood pressure control.[5] It has been estimated that more than 70% of patients with resistant hypertension also have underlying OSA.[6,7]

Currently, it is hypothesised that restricted airflow in patients with OSA results in episodic hypoxaemia and hypercapnia. These induce an autonomic response together with catecholamine surges, which result in vasoconstriction and associated transient episodes of hypertension. In time, this mechanism of persistent sympathetic stimulus causes the development of sustained systemic hypertension.

Continuous positive airway pressure (CPAP) remains the first line treatment for patients with OSA,[1,3] and its

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beneficial effects on systemic blood pressure have been well documented.[7,8] Adherence, however, remains a problem for about 40% of patients.[9,10] Other non-invasive treatments have been used, most commonly mandibular advancement devices, and a small number of published studies have reported beneficial effects on blood pressure.[11,12] Patients who cannot tolerate these interventions can be treated surgically, and maxillomandibular advancement is thought to be as effective as CPAP,[13,14] but we know of little research on its effects on blood pressure.

We sought to assess to what extent maxillomandibular advancement surgery influences patients systemic blood pressure postoperatively. We therefore explored the changes in systolic and diastolic blood pressure, and mean arterial pressure both pre- and postoperatively in a consecutive group of patients who had undergone maxillofacial orthognathic surgery at our institution.

Method

We retrospectively reviewed the outcome of a group of consecutive patients who had maxillomandibular advancement surgery for OSA at our hospital between 2002 and 2012. All had been diagnosed after clinical assessment and polysomnographic evaluation. They had subsequently failed to adhere to CPAP and other non-invasive treatments.

We obtained relevant details from the medical records, which included characteristics, medical history, clinical and operative data, and results of preoperative and postoperative sleep studies. In each patient we also collected preoperative blood pressure (systolic, diastolic, and mean arterial pressure) and corresponding postoperative data taken no less than 6 months after surgery. Blood pressure was measured on at least 2 occasions with a standard digital automatic monitor when patients were sitting down, the first at the initial assessment by sleep clinicians and the second at the nurse-led preoperative assessment clinic. The lowest reading of the 2 was recorded. In the case of patients with established hypertension, previously documented blood pressures and prescribed medication were noted.

We compared the mean blood pressure values before and after operation in all patients accordingly, and analysed data on those with established hypertension to find out whether changes in haemodynamic variables were different. We also explored a possible association between surgical success and effect on systemic blood pressure.

The severity of OSA depends on the apnoea/hypopnoea index (AHI), which is an objective measure calculated from a sleep study (mild = AHI 5–14 h^{-1}, moderate = AHI 15–30 h^{-1}, severe = AHI over 30 h^{-1}). For the purposes of our study, surgical success was taken as a postoperative AHI of less than 15 and a 50% reduction in the index from baseline.

Data were analysed using SPSS for Windows version 10.1. The means (SD) of continuous variables were compared using a paired *t* test. Variables that were not normally distributed were compared using the Wilcoxon rank-sum test.

Table 1
Baseline characteristics of the study sample. Data are number (%) unless otherwise stated.

	No. of patients ($n = 51$)
Mean (SD) age (years)	44 (8)
Sex	
Male	46 (90)
Female	5 (10)
Mean (SD) BMI	29 (3)
Smokers	14 (28)
Alcohol consumption	40 (78)
Coexisting conditions	
CVS	11 (22)
Respiratory	6 (12)
Other	2 (4)
CPAP	
Used	44 (86)
Not used*	7 (14)

BMI = Body mass index; CPAP = continuous positive airway pressure; CVS = cardiovascular condition.
* Declined CPAP or used it for less than 4 weeks.

Table 2
Comparison of mean (SD) preoperative and postoperative blood pressure in the overall group ($n = 45$).

	Preoperative	Postoperative	*p* Value
Systolic	131.4 (12.6)	127.6 (12.5)	<0.001
Diastolic	79.9 (10.9)	77.4 (9.5)	0.23
Mean arterial pressure	96.6 (10.2)	93.1 (8.4)	0.06

The chi square test was used to compare categorical variables. Probabilities of less than 0.05 were considered significant.

Results

Of the 51 patients identified, 45 were included as data on blood pressure before and after operation were available. The baseline characteristics of the group are shown in Table 1. The mean (SD) preoperative body mass index (BMI) was 29 (3.4); postoperatively it was 28 (3.1). The difference was not significant. Table 2 shows mean systolic and diastolic blood pressure, and mean arterial pressure before and after surgery.

Ten patients had a documented diagnosis of hypertension. Analysis of the blood pressure variables in this group showed marked improvement in systolic (median value with interquartile range (IQR) preoperative 140 mmHg (11) and postoperative 132 mmHg (10), $p = 0.06$) and diastolic blood pressure (median (IQR) preoperative 91 mmHg (9), postoperative 81 mmHg (7), $p = 0.03$), and MAP values (median (IQR) preoperative 106 mmHg (9), postoperative 97 mmHg (7), $p < 0.01$) (Fig. 1).

Data on AHI scores pre and postoperatively were available for 39 of the 51 patients, and 33 (85%) met the criteria for surgical success. When we stratified our sample into 2 groups based on surgical success, we found no significant variance in postoperative blood pressure (mean (SD) systolic: 127.5 (12.6) compared with 130.1 (8.1); diastolic: 76.5 (9.5) compared with 75.2 (5.6)). Blood pressure modification in the

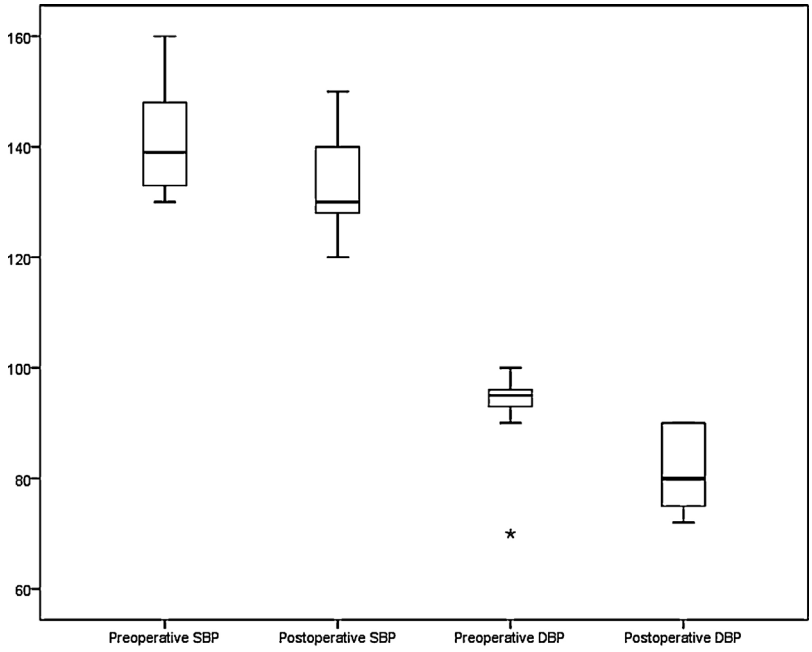

Fig. 1. Box and whisker plot showing blood pressure (mmHg) before and after operation in patients with established hypertension ($n = 10$).

Table 3
Mean (SD) changes in blood pressure in patients who did not meet the criteria for surgical success.

	Preoperative	Postoperative	*p* Value
Systolic	132.8 (11.6)	130.1 (8.1)	0.57
Diastolic	86.1 (8.5)	75.2 (5.6)	0.01
Mean arterial pressure	100.2 (6.3)	93.4 (3.2)	0.02

6 patients who did not meet the criteria for surgical success is summarised in Table 3.

Discussion

The aim of this study was to explore the possible relationship between maxillomandibular advancement surgery and blood pressure modification in a cohort of patients with OSA. It has been reported that the risk of cardiovascular disease increases 5-fold in patients with untreated OSA.[15]

The mean (SD) postoperative systolic blood pressure was significantly reduced in our sample following surgery (from 131(12.6) to 127 (12.5) mmHg, $p < 0.001$). The mean (SD) reduction in postoperative mean arterial pressure in the overall group, approached statistical significance. Diastolic blood pressure readings were also lower postoperatively, but the difference was not significant. Overall the values for systolic and diastolic blood pressure, and mean arterial pressure, were lowered by 3.8 mmHg, 2.5 mmHg, and 3.5 mmHg, respectively. Our findings compare favourably with those in a recent randomised controlled trial that reported reductions with CPAP of around 2.1 mmHg for systolic, and 1.3 mmHg for diastolic blood pressure.[8]

Difficulties with treatment adherence may explain why systemic blood pressure appears to improve more after maxillofacial surgery than after use of CPAP in OSA patients. Compliance is often described as use of CPAP for 4 h a night for at least 70% of nights,[16] consequently a patient who sleeps for in total 7 h a night could be considered compliant, despite spending up to 40% of their total sleep duration without CPAP. Sleeping without CPAP for an appreciable period may diminish its effect on blood pressure whereas maxillomandibular advancement provides permanent upper airway modification, independent of patient adherence to treatment. Over a prolonged follow up period surgical intervention may be shown to be more efficacious in counteracting the pathophysiological mechanisms that contribute to hypertension in patients with OSA.

Ten patients in our series had a known diagnosis of hypertension and review of their records showed that none required escalation in their drug regimen following surgery. Two of them had resistant hypertension. In one who had previously required multiple drugs, blood pressure was successfully controlled with a single agent and at a lower maintenance dose. Analysis of the blood pressure variables in this group showed considerable improvements. Overall median systolic, diastolic, and mean arterial pressure was reduced by 6 mmHg, 10 mmHg, and 9 mmHg, respectively, after surgery. Consequently, the reduction in blood pressure values in this group was greater than that observed in the group overall.

We found no significant differences in blood pressure between those who met our criteria for surgical success (postoperative AHI less than 15) and those who did not, which suggests that improved control of blood pressure and

modification in cardiovascular risk is comparable irrespective of objective outcome data from postoperative sleep studies. This finding supports the argument that "success" based on postoperative AHI alone is somewhat arbitrary and gives an incomplete picture. Although postoperative AHI is undoubtedly important and correlates with physiological changes, it may not reflect associated improvements in clinical outcomes, in particular reduction in cardiovascular risk.

Previous research has shown that CPAP and use of mandibular advancement devices both have beneficial effects on blood pressure in patients with OSA,[7,8,11,12] but we identified only 3 studies that provide data on improvements after maxillomandibular advancement surgery. Prinsell[17] reported on 50 patients all of whom achieved surgical success. In addition to the improvement in objective polysomnographic data, there were significant improvements in systolic and diastolic pressures 5.2 months postoperatively (mean reduction of 15.0 and 9.6 mmHg, respectively). Riley et al.[18] reported on a series of 40 patients who had maxillomandibular advancement surgery for OSA, 13 of whom had a history of hypertension that required medication. Although they reported no data on changes in blood pressure after operation, the authors mentioned that in 7 of the 13 patients a dramatic improvement in blood pressure allowed them to reduce or stop their medication. Similarly, Goh and Lim[19] studied 11 patients who had jaw advancement for OSA, and 4 of them had a documented history of hypertension. Six months postoperatively, one was normotensive without medication, and blood pressure in the remaining 3 was better controlled.

Our findings are in keeping with those of Prinsell.[17] We observed improvements in our group overall, and particularly in those with known hypertension. We also noted equivalent benefits in those who did not meet the criteria for surgical success.

The limitations of this study include its relatively small sample size, and one can also speculate about the potential effect of "white coat" hypertension. While all our patients had their blood pressure taken in a clinical setting, at least one reading was obtained before referral to maxillofacial outpatient clinic, which may perhaps offset the potential additional effect of anxiety in those referred for surgery and its consequent impact on blood pressure. Patients with established hypertension had well documented blood pressures and drug histories.

In our analysis we considered confounding variables including BMI, smoking history, and medication for hypertension. We found no significant difference in the mean BMI before and after operation, which suggested that hyperobesity was not an important contributing factor in the blood pressures in the group. No patients with known hypertension were given additional medication to control their blood pressure in the postoperative follow-up period, and the patient with the most resistant hypertension was successfully managed on a reduced regimen.

Our findings suggest that in addition to being a highly effective treatment for OSA, maxillomandibular advancement may potentially be more potent than CPAP in reducing systemic blood pressure. Further studies are needed to investigate beneficial trends in cardiovascular risk factor modification observed in patients with obstructive sleep apnoea following maxillofacial surgery.

Conflict of interest statement

We have no conflicts of interest

Ethics statement

None.

Acknowledgment

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